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PACIFIC SOUTHWEST
FOREST AND RANGE
EXPERIMENT STATION
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FOREST SERVICE - U. S. DEPARTMENT OF AGRICULTURE

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Have you ever tried to use paint that had too much thinner? If you have, you know that it drips and runs. But paint that is "just right" stays in place. This property of a liquid that causes it to adhere to a solid surface--viscosity--is also valuable for materials used in coating the surface of fuels to retard and suppress wildfires.

Viscous water and algin gel are two new materials designed to "stay put" on fuels. They have been tested extensively to determine their characteristics and their effectiveness on different types of fuels. They are only two of many chemicals being investigated to find more efficient fire-control materials (Davis, Dibble, and Phillips 1961).

This report describes the characteristics and uses of viscous water and algin gel in laboratory and field tests and in trials on more than 200 forest and wildland fires over a 2-year period.

VISCOUS WATER

Viscous water is plain water thickened to the consistency of light motor oil by adding a small amount of white- or buff-colored powder that resembles cornmeal. Chemically this mixture consists of polymers (long-chain molecules) that can attract and hold nearby water molecules. Fibers or threads of water that tend to unite are produced, and the water becomes viscous, or sticky. The degree of thickness depends upon several factors, including the quantity and type of viscous agent used, salt content of the water, and air temperature. Water thickened to about the viscosity of light motor oil (100-200 centipoise)[1/] clings to vegetation, yet pumps and handles easily.

The two viscosity agents most often used in fire retardants are sodium alginate, made from giant kelp, and sodium-carboxymethyl-cellulose (CMC).[2/] They are non-toxic; they are widely used, for example, in the manufacture of such food products as ice cream and pie filling, but they may become slightly toxic if preservatives are added to prolong storage under some conditions. Large amounts would have to be consumed, though, and this is not likely because of the material's viscosity.

1/ Measured with Brookfield viscometer model LVF, spindle No. 4, 60 r.p.m., 70°F.

2/ Sodium alginate was supplied for this study by the Kelco Company, 530 W. Sixth Street, Los Angeles 14, California. Sodium-carboxymethyl-cellulose was supplied for this study by the Hercules Powder Company, 120 Montgomery Street, San Francisco 4, California.

ALGIN GEL

Algin gel is a thick viscous water produced by adding a small amount of calcium chloride solution to water mixed with algin. The calcium chloride binds the water fibers together. The resulting structure is similar to gelatin--rigid and strong enough to support its own weight. The rigidity allows a thick layer of gelled water to build up even on vertical fuel surfaces (fig. 1). The layer absorbs much heat and thus insulates the fuel. Algin gel holds water tenaciously and drys slowly. In humid areas it may remain moist for several days.

More algin gel and viscous water are retained on the surface of vegetation than when plain water is applied. Experiments with dowels dipped in a viscous mixture show that the amount of liquid retained on the surface is related to the viscosity of the mixture (fig. 2) (Langguth 1961).

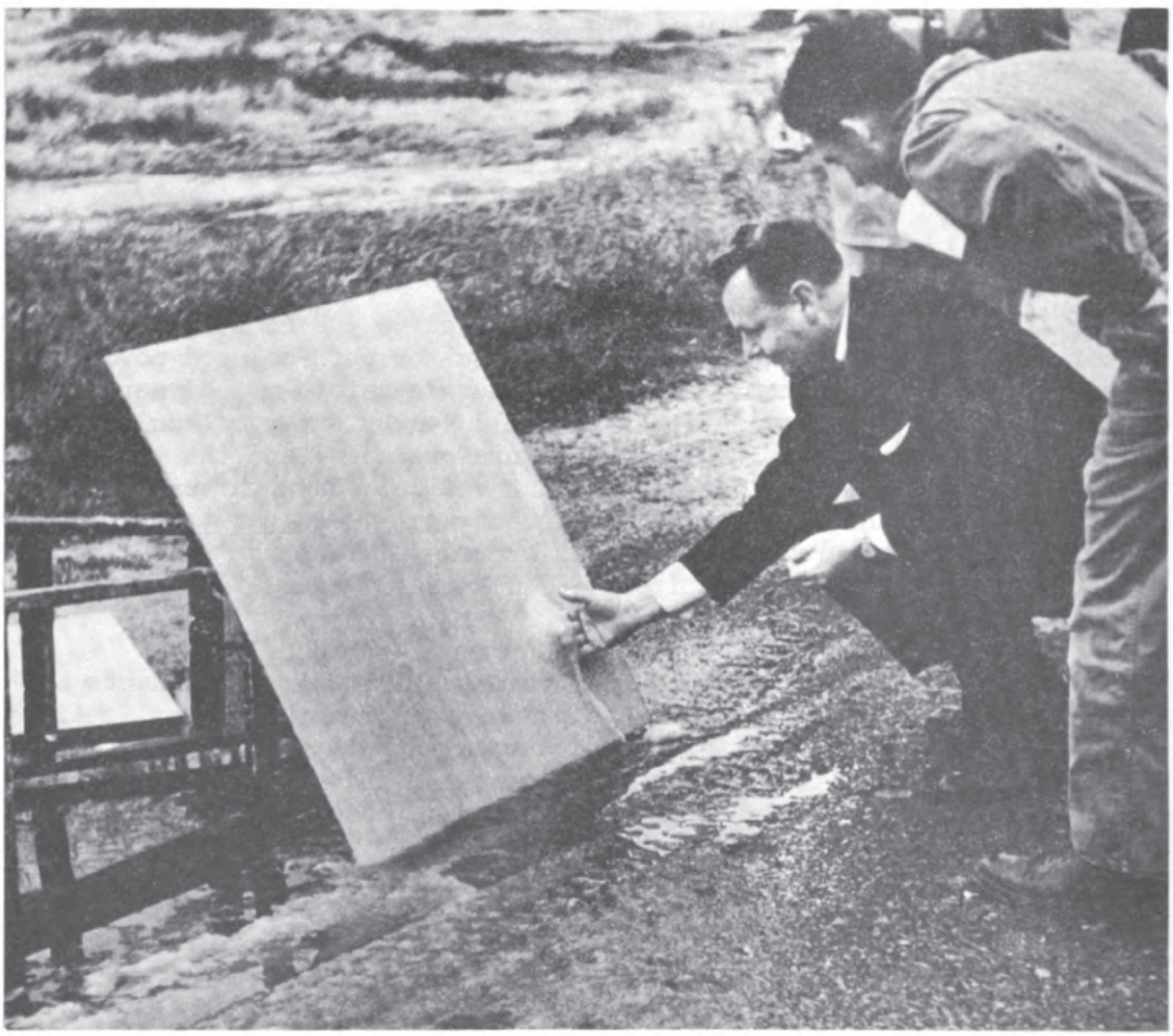

Figure 1.--Algin gel forms a thick layer when sprayed onto a vertical plywood panel.

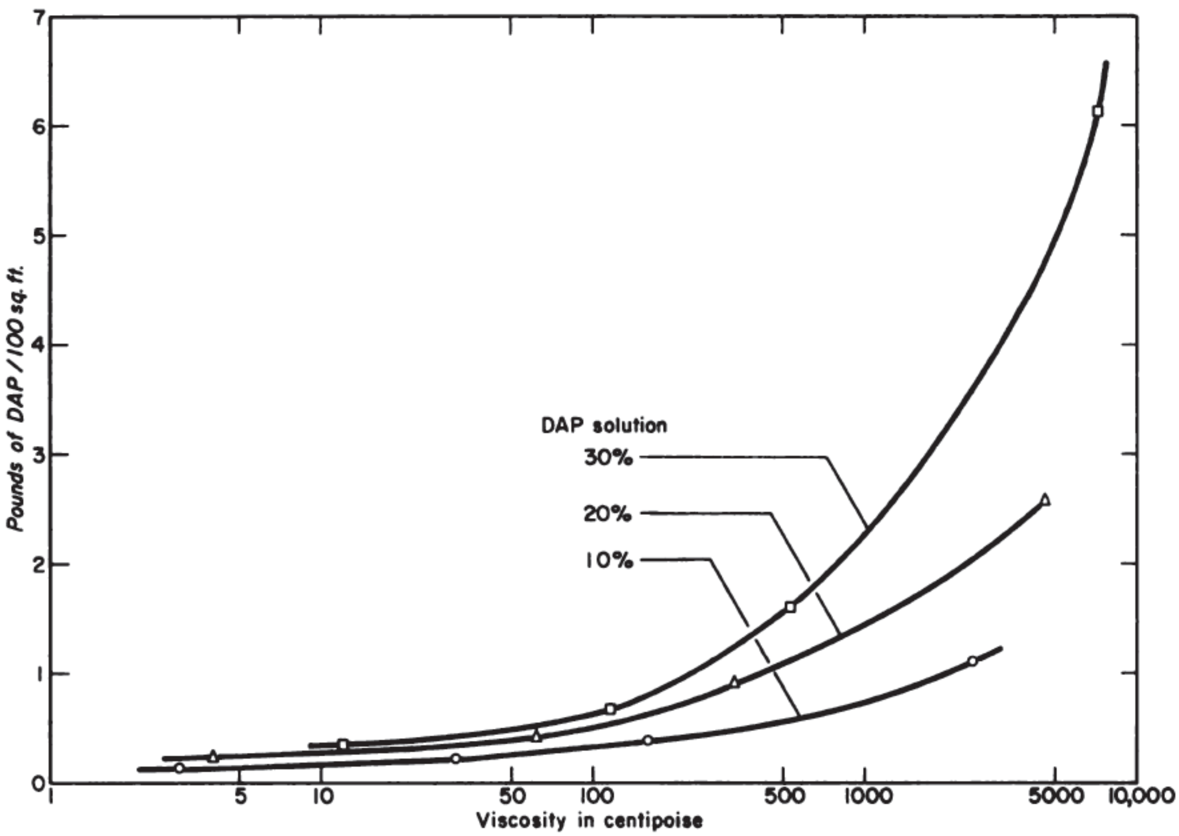

Figure 2.--Retardant retained on fuel is a function of viscosity (Monsanto Chemical Co. data).

The two materials also have other advantages. Their cost is reasonable, ranging from 3 to 6 cents per gallon for both. While water thickened with algin gel or CMC has only a very slightly higher boiling point than plain water, more heat is required to evaporate the greater amount of viscous water or algin gel spread on the fuel surface. Also, both materials form a film on the fuel surface that drys to a tough oxygen-excluding layer (fig. 3).

LABORATORY TESTS AND RESULTS

The basic idea of fighting fires with viscous water stems from laboratory studies conducted by the Syracuse University Research Institute under a contract with the United States Navy (Aidun 1960, 1961). These studies indicated that viscous water was several times more effective than plain water in extinguishing laboratory fires. Test results demonstrated that suppression time was reduced by one-fourth and the rate of rekindling was lowered materially (figs. 4 and 5). Trial procedures included suppressing test fires in small wood cribs under controlled conditions.

The Pacific Southwest Forest and Range Experiment Station has conducted retardant tests using algin gel. Its findings indicated that for temperature ranges from 1,000°F. to 1,700°F. and for drying time up to 5 hours, sodium alginate gel excelled either bentonite or borate, two commonly used retardants, in keeping test fuels from igniting (fig. 6).

Figure 3.--Snag was coated with algin gel while tarpaulin covered fuel at the base. Fuel was fired immediately after application of gel. The snag eventually burned off at the base and fell over, and upper portions revealed no signs of burning or charring.

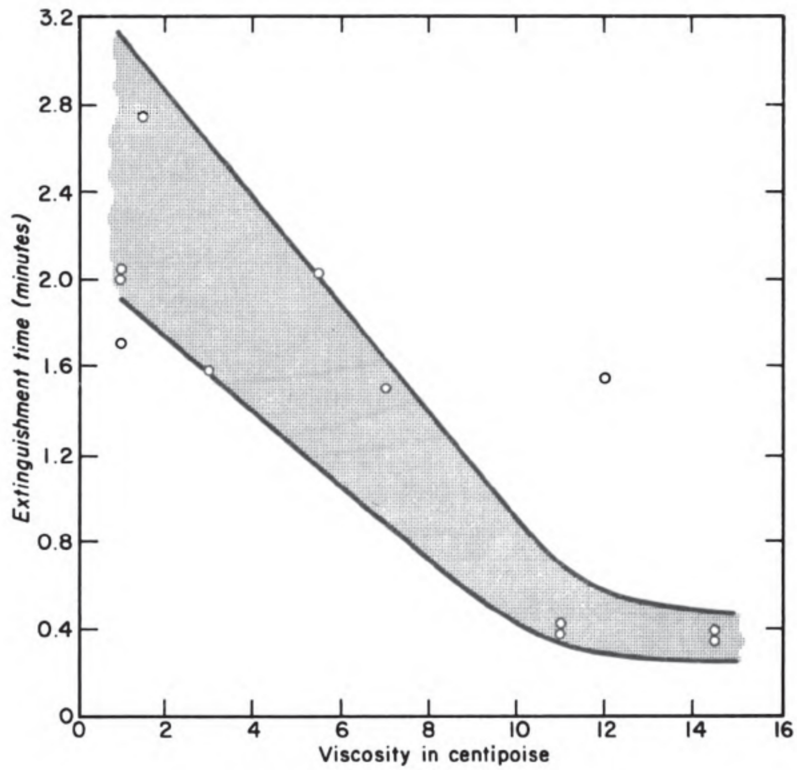

Figure 4.--Effect of retardant viscosity on suppression time (Monsanto inspissator test, DX-840-91, 1 g.p.m. flow rate) (Aidun 1960).

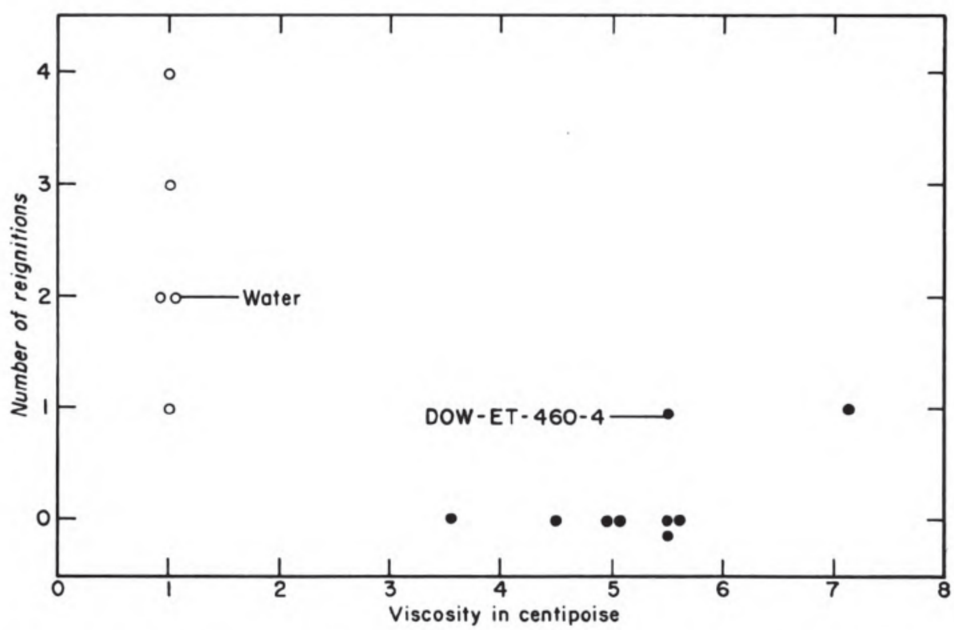

Figure 5.--Reignitions of test fuels treated with retardants of different viscosities (4 minutes of pre-burn and 3.6 g.p.m. flow rate) (Aidun 1961).

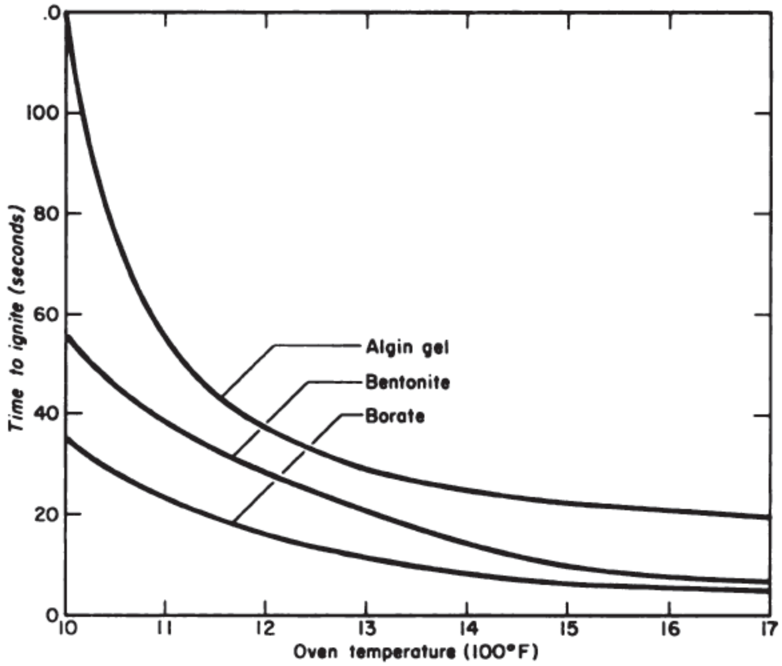

Figure 6.--Dowels dipped in algin gel do not ignite as rapidly as those coated with bentonite or borate.

FIELD TESTS AND RESULTS

The first field tests of thickened water were conducted at Mariposa in central California in June 1960 (U.S. Forest Service 1960). Since then additional tests have been held by other agencies on a large variety of fuel types in several locations, including the following: (a) Ramona, California (Phillips 1961a); (b) Cathay, California (Phillips 1961b); (c) Medford, Oregon (Maul 1961); (d) Rickreal, Oregon (Brown 1961); (e) Olympia, Washington (Beswick 1961); and (f) Norfolk, Virginia (Aidun 1961). The tests included both mixing and handling trials and tests for fire suppressing and retarding effectiveness.

Most of these tests measured the extinguishment time or the reduction in rate of spread through treated portions of natural fuels or wood cribs. Considerable effort was made to standardize the fuels and use uniform techniques, but all tests were conducted out-of-doors and consequently were subject to variations in weather conditions. The data in most cases did not suit rigorous statistical analysis, but records of extinguishment time, radiation, and rate of spread reduction indicate definite trends or patterns in the effectiveness of the materials tested.

Phillips (1961a, 1961b) found that viscous water retarded the spread of fire for a short time only; the thick algin gel was an effective retardant in both light and heavy fuels for several hours (tables 1 and 2). In fuel beds of dry white fir and Douglas-fir trimmings, equivalent to 53 tons of fuel per acre, algin gel was the only one of several retardants tested that completely prevented penetration of the fire into the treated area (Brown 1961).

Table 1.--Effect of various retardants on spread of fire in grass plots

Retardant	Drying time			
	1 hour	2 hours	3 hours	4 hours
Water	Burn through	Not tested	Not tested	Not tested
Viscous water 1/	Complete stop	Partial stop 2/	Burn through	Not tested
Algin gel "A" 3/	Complete stop	Complete stop	Burn through	Not tested
Algin gel "B" 4/	Not tested	Not tested	Complete stop	Burn through
Algin-DAP 5/	Complete stop 6/	Complete stop 6/	Not tested	Not tested

1/ 1 percent KNF algin solution (0.083 pounds per gallon of water).

2/ Stopped along most of line but fire crept through in two places where application of retardant was light.

3/ Low viscosity gel (1 percent KNF algin plus low concentration of calcium chloride, about 1:600).

4/ Medium viscosity gel (1 percent KNF algin plus medium concentration of calcium chloride, about 1:400).

5/ 0.75 percent KXFF algin and 15 percent DAP (0.06 pounds of algin and 1-1/4 pounds of DAP per gallon of water).

6/ Grass was charred where touched by advancing flames, but combustion was not sustained.

SOURCE: Phillips 1961a, 1961b.

Table 2.--Effect of various retardants on spread of fire in brush plots

Retardant	Drying time		
	1 hour	2 hours	3 hours
Water	Burn through	Not tested	Not tested
Viscous water 1/	Complete stop	Complete stop	Burn through
Algin gel "A" 2/	Complete stop	Complete stop	Partial stop 3/
Algin gel "B" 4/	Not tested	Not tested	Complete stop
Algin-DAP 5/	Not tested	Complete stop 6/	Not tested

1/ 0.8 percent KNF algin solution (0.068 pounds per gallon water).

2/ Medium viscosity gel (0.8 percent KNF algin plus medium concentration of calcium chloride, about 1:400).

3/ Burned through about 4 feet of center of treated strip. Remainder of strip stopped fire.

4/ High viscosity gel (0.8 percent KNF algin plus high concentration of calcium chloride, about 1:300 or less).

5/ 0.6 percent KXFF and 12 percent DAP (0.04 pounds of algin and 1 pound of DAP per gallon of water).

6/ Actually tested at the end of 2 hours and 20 minutes of drying.

SOURCE: Phillips 1961a, 1961b.

OPERATIONAL TESTS AND RESULTS

Field tests were extensive, but they left many questions unanswered. We needed more information on the suppressant and retardant effects of viscous water and algin gel under a wide range of burning conditions and fuel types. We wanted to know how well they could perform in both the non-critical situation and in critical fire situations when they had to be mixed and used. We got our answers from fighting 218 forest and wildland fires over a 2-year period.

During 1960 six crews of four fire agencies tested viscous water on grass, brush, timber, and structural fires throughout California and Nevada (Davis, Dibble, and Phillips 1961). In 1961 the number of test crews was increased to 24 and distributed in such a way that all major California and western Nevada fuel types were covered (fig. 7). To test algin gel, crews from two Forest Service stations--Descanso and Mount Shasta--and from six California Division of Forestry stations--Cathay, Eldorado, Flynn Springs, Garberville, Paso Robles, and Sterling City--were given calcium chloride mixing equipment in addition to viscous water equipment.

Each time the crew foreman used viscous water on a fire he filled out an evaluation form (fig. 8). These forms were forwarded to this Station where the data were transferred to punch cards. At the end of the 1961 fire season, representatives from this Station and the cooperating agency interviewed each test crewmen. They tape recorded replies to a standard list of questions on fire control effectiveness, crew training requirements, and operational problems with viscous water and gel.

During the 1960 and 1961 fire seasons crews used viscous water on 212 forest fires and algin gel on 6 fires. The foremen's evaluations of fire control effectiveness were grouped into four categories: (a) positive help, meaning that the foreman had no doubt in his mind that viscous water was superior to plain water and that he often had a direct comparison; (b) probable help, meaning that viscous water probably was superior, but the observer was not sure; (c) doubtful or no help, indicating that the observer either felt or was sure that viscous water was no better than plain water; (d) adverse effect, indicating that the foreman believed or was certain that plain water would have done a better job.

The data from these evaluations show that viscous water was positively or probably superior to plain water on 180, or 85 percent, of the fires (table 3). On 27 fires it was considered of little or no help. Plain water would likely have done a better job on 2 percent of the fires. Data are very limited for algin gel, but the chemical appears to be superior to plain water on about two-thirds of the fires on which it was used. Experience has shown that although a fire in heavy fuel may not be completely extinguished by algin gel, it can reduce the fire's intensity enough that men using hand tools can easily mop up.

The foremen's evaluations indicated little difference in the effectiveness of viscous water when used on different fuel types (table 4).

Figure 7.--Distribution of test crews throughout California and Nevada.

FIRE FIGHTING CHEMICAL TESTS - GROUND EQUIPMENT

GENERAL

(1)Agency________(2)Forest or Unit______________ Name of Fire____________________

(3)Date of Origin__________ (4)County or Supervisor's Fire No.____________________
Mo./Day/Yr.

(5)Date of Chemical Use__________Location(6)Twp.______(7)Rge.______(8)Sec.___(9)Mar.___
Mo./Day/Yr.

(10)Type of Chemical____________(11)Gallons of Chemical Mixed Used______________

FIRE AND WEATHER CHARACTERISTICS (During Time and Place of Chemical Use)

(12)Time of Day____(AM)(PM)(13)Fire Danger Rating Area No._____(14)Area Avg. BI______
Hour

(15)Temperature____(16)Humidity_____%(17)Wind Speed_____(18)Wind Direction__________

(19)Nearest Fuel Moisture Stick Reading__________%

Note: Check only one in each item of 20 thru 31.

(20)Rate of Fire Spread:	(21)Topography:	(22)Slope(%):	(23)Aspect:	(24)Elevation(ft.):
Smoldering___	Ridge top ___	0-19___	North___	0-1000___
Creeping ___	Saddle ___	20-39___	East ___	1001-2000___
Running ___	Upper 1/3 slope___	40-59___	South___	2001-3000___
Spotting ___	Middle 1/3 slope___	60-79___	West ___	3001-4000___
Crowning ___	Lower 1/3 slope___	80-99___	NE ___	4001-5000___
Violent ___	Canyon Bottom ___	Over 100___	SE ___	5001-6000___
	Valley ___		SW ___	6001-7000___
			NW ___	7001-8000___
			Flat ___	Over 8000___

(25)Chemical Use on Fire:	(26)When Used on Fire:	(27)Type of Attack:
Head ____	Initial attack____	Direct ____
Flank ____	Follow up ____	Indirect ____
Rear ____		Back fire____
Backingdown____		Mop up ____
Other ____		

(28)Fuel Type on Area:

Grass ___	Heavy mixed brush ___
Grass and sage ___	Heaviest mixed brush ___
Bear clover ___	Woodland ___
Light to med. chamise - S. Calif. ___	Mature timber ___
Brush mixed with sage ___	Timber - med. reproduction and brush___
Med. brush in cutover timber burn ___	Mixed fir - reproduction and brush___
Med. brush and oak - S. Calif. ___	Second growth - poles ___
Hvy. pure chamise, manzanita or buckbrush___	Slash ___
Open manzanita ___	Structure ___
	Other (__________) ___

(29)Initial Effect:	(30)Residual Effect:
Fire put out ____	Fire stayed out ____
Temporarily knocked down ____	Rekindled ____
Slowed ____	Burned through ____
Not effected ____	Other ____

(31)Overall Effect:

Positive help ____	No help ____
Probable help ____	Probable adverse effect____
Doubtful help ____	Positive adverse effect____

(32)Remarks: (Please write on back)

PSW, 4400-4

Figure 8.--Crews evaluated viscous water and algin by filling out this form.

Table 3.--Summary of fire evaluation reports

Evaluation	Viscous water used on fires		Algin gel used on fires	
	Number	Percent	Number	Percent
Positive help	101	48	4	66
Probable help	79	37	0	0
Doubtful or no help	27	13	1	17
Adverse effect	5	2	1	17
Total	212	100	6	100

Table 4.--Evaluation of the effectiveness of viscous water on different fuel types

Fuel	Positive help	Probable help	Doubtful or no help	Adverse effect	Basis, number of fires
	Percent				
Grass	46	40	12	2	55
Light brush	48	41	7	4	27
Heavy brush	55	27	18	--	33
Slash	44	56	--	--	9
Woodland	56	22	11	11	9
Timber	27	40	27	6	15
Structures	50	50	--	--	20
Miscellaneous 1/	50	32	16	2	44

1/ Includes vehicles, piled lumber, baled hay, and others.

In all cases in which viscous water was used on slash or structural fires it was rated either a positive or probable help.

Viscous water was least effective in timber fires. Analysis of the types of use tells us why. Viscous water was used on 15 timber fires: eight times on first attack and seven times on mopup. In all of the initial attack applications and in two of the mopup, viscous water was considered a positive or probable help. However, in five of the mopup applications viscous water was rated equal or inferior to water. Penetration into deep duff proved to be the big problem.

The evaluations indicated viscous water was slightly more effective in direct attack than on mopup (table 5). However, this difference may be due to the duff problem. Meticulous care is required in mopup. When applied properly viscous water went further, and fewer rekindles occurred than with plain water.

Table 5.--Evaluation of the effectiveness of viscous water on direct attack and mopup

Use	Positive help	Probable help	Doubtful or no help	Adverse effect	Basis, number of fires
	- - - - - - - -	- - - Percent	- - - - - - - -		
Direct attack	51	36	11	2	154
Mopup	38	40	19	3	58

Viscous water was given a favorable rating (positive and probable help) on about 80 percent of all fires (fig. 9). However, on the more intense fires the rating of positive help increased and the rating of probable help decreased, indicating either that the material was more effective on hot fires or that less doubt of its effectiveness developed.

The tape recorded interviews of the test crews indicated that they wanted to continue using viscous water on an operation basis. Many of their answers were qualified, however, and most of their responses fit a pattern. Crews that used viscous water on many hot fires were usually enthusiastic about the chemical. Crews that responded to few fires or to low intensity fires usually were less inclined toward the material. They found themselves mixing, handling, and measuring a material that only occasionally gave them any marked advantage.

The crews generally agreed that lack of penetration, slipperiness, and problems associated with mixing and handling viscous water were the biggest drawbacks. They also agreed that the viscous material should be mixed only when needed and that improved mixing equipment tailored to the pump capacity of their trucks was needed. All crews said that they had

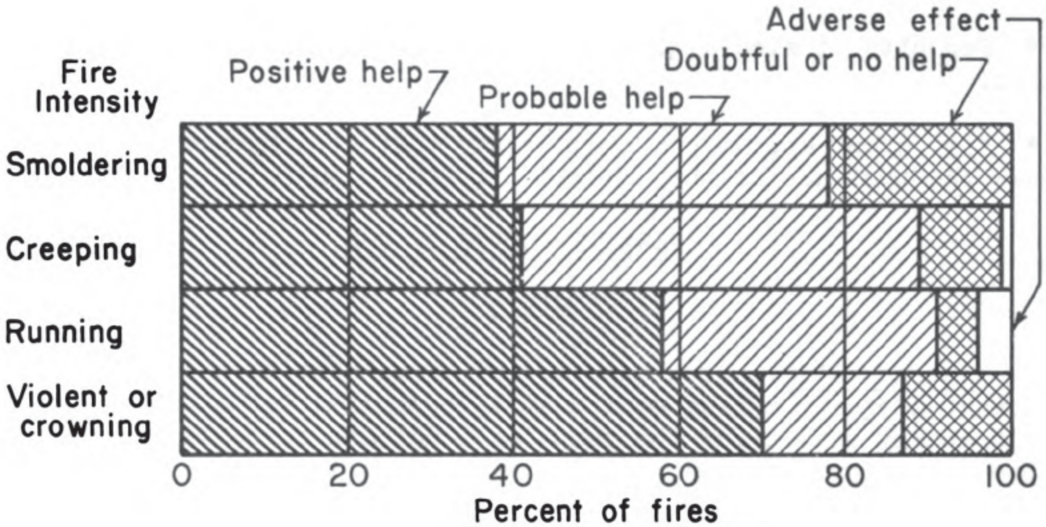

Figure 9.--Crews seemed to be more certain about the effectiveness of viscous water as fire intensity increased.

received excellent technical service from the manufacturers, and that in most cases they had been kept informed of latest developments and of what other crews were doing.

The biggest disagreement concerned the kind of fuels the materials would work best in. Some crews had good results in the initial attack on heavy fuels and poor results in mopup. Others claimed that viscous water went much further than plain water when used in mopup, but they preferred plain or wet water for down logs, stumps, and the like.

PERFORMANCE ON WILDFIRES

The performance of viscous water and algin gel on wildfires can be summarized as follows:

- Viscous water is more effective than plain water for knocking down hot fires in most forest fuels. Both viscous water and algin gel act best on hot fires and are probably not needed on low intensity fires.

- Fires mopped up with viscous water do not rekindle as rapidly as those mopped up with plain water. However, viscous water does not penetrate deeply into the litter and duff, and must be mixed or stirred in.

- Algin gel can be an effective fire retardant for several hours. It works well on heavy fuels, such as logging slash and structures. It protects areas exposed to intensive or prolonged heat.

- Friction loss, or loss of nozzle pressure because of increased friction, is associated with viscosity. But this loss was not a seriously limiting factor. Crews have used 2,500-foot hose lays.

• Deposits of zinc-alginate on galvanized tanks can be a serious problem.

• Fire crews applying viscous water must be competent and well trained to make the best use of this chemical in fire control.

CHARACTERISTICS OF USE

MIXING

Viscous water.--Fire suppression crews that have used viscous water agree that adequate mixing equipment is essential for success. A good mixer properly scaled for the pump and truck and correctly installed can combine the water and powdered viscosity agent in a few minutes. Most crews carried enough powdered viscosity agent on their trucks for several loads. One crew mixed seven loads during one fire. Crewmen who did not have adequate equipment, particularly early in the study program, probably wished that they had never heard of viscous water.

The eductor is a practical mixing device that operates on the jet aspirator principle. Water from the pump flowing at high velocity through a narrow passageway sucks the powder into the swift-moving stream of water (fig. 10). The extreme turbulence caused by the high velocity separates, disperses, and thoroughly soaks each grain of powder. The suction of the eductor depends upon the velocity and volume of the water which flows through it. Consequently the device should be tailored to each truck's pump capacity (U.S. Forest Service 1961). A simple eductor can easily be made in almost any metal shop from standard pipe fittings at less than $20 in cost for materials (fig. 11).

If not properly mixed, most viscosity agents tend to lump or cluster when they first contact water. These clusters become surrounded by a gelatinous coating which greatly lengthens the time required for complete solution and, if large enough, may clog smaller diameter plumbing or jam the mixing equipment (fig. 12).

Algin gel.--To mix algin gel add calcium chloride to viscous water in one of three ways. Each method has advantages and disadvantages.

The dual hose system uses a small calcium chloride pump synchronized with the main water pump. The calcium chloride in a small tank is pumped through its own small diameter hose into a special mixing nozzle (fig. 13). This method allows the nozzle man to select quickly the viscous water or the gel, depending on the fuel and fire situation. But it has two disadvantages: An extra pump is required, and the length of the hose is limited to that of the dual hose.

In the backpack system, the nozzle man wears a specially designed backpack tank containing concentrated (37 percent) calcium chloride water solution (fig. 14). The tank also has a metering device that proportions the proper amount of calcium chloride to the algin-thickened water. This

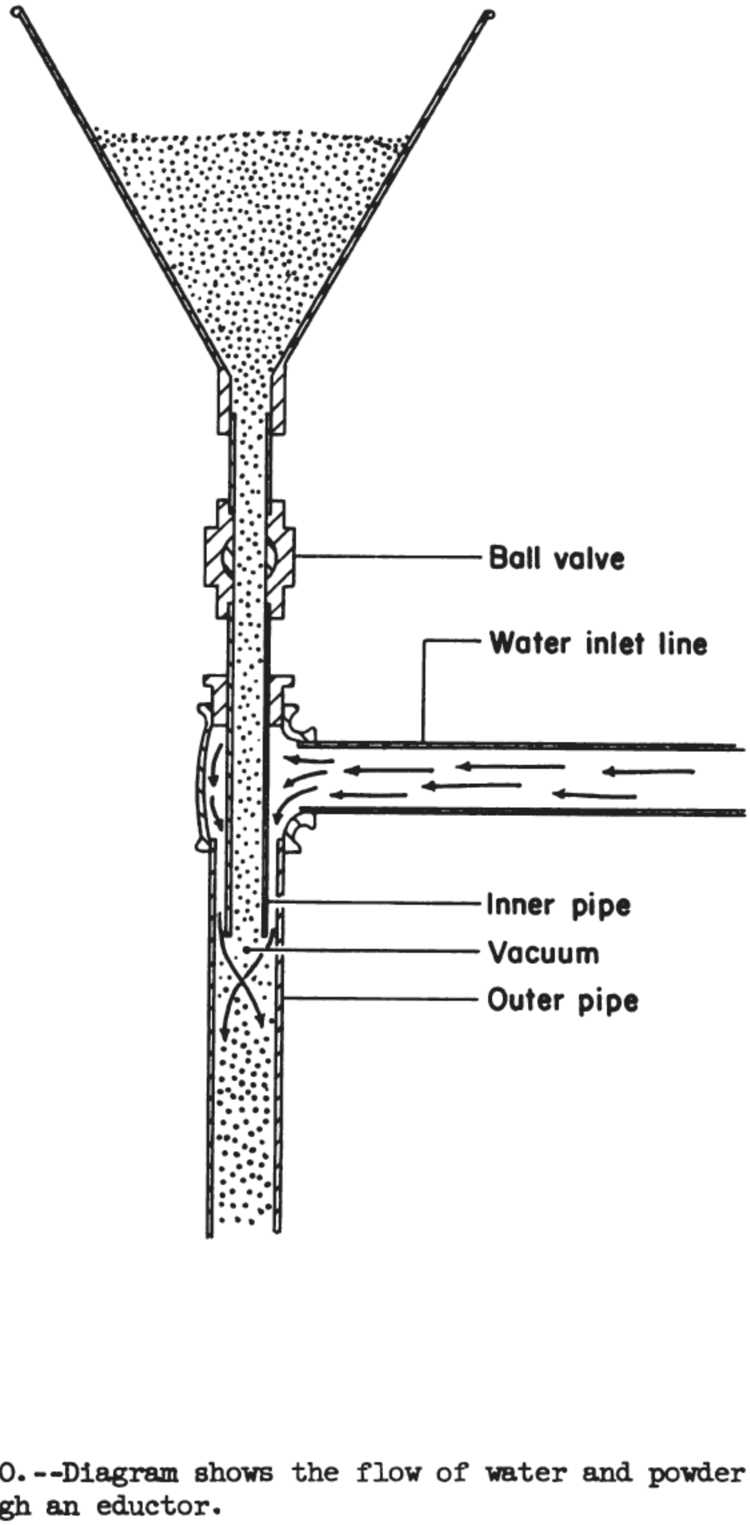

Figure 10.--Diagram shows the flow of water and powder through an eductor.

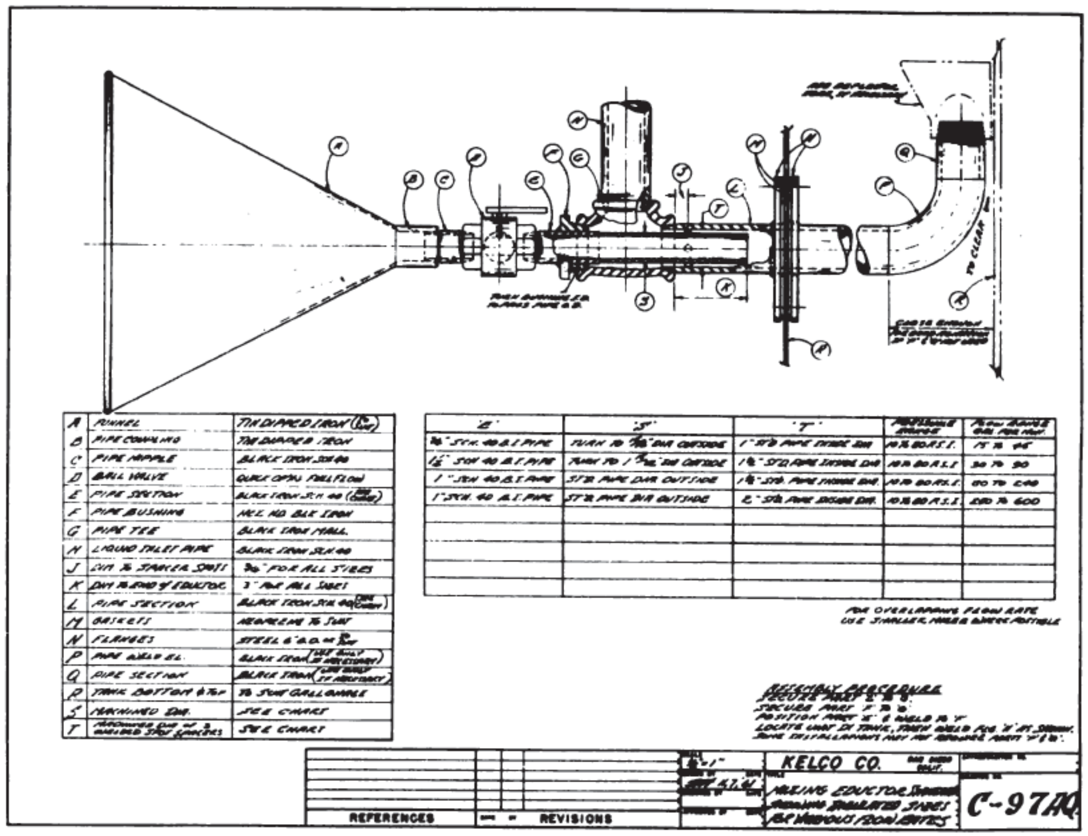

Figure 11.--Eductor specifications for various pump capacities.

Figure 12.--Viscosity agents can become lumpy or form clusters, and may clog equipment if not mixed properly when combined with water.

method allows a quick selection of viscous water and gel and does not restrict the length of fire hose. It has the disadvantage of burdening the nozzle man by forcing him to carry 28 to 30 pounds on his back and a rather heavy mixing nozzle.

In the pump mixing system, calcium chloride can be metered into the algin-thickened water by a venturi device on the intake side of either a rotary gear or centrifugal pump (fig. 15). The two liquids are then thoroughly mixed while flowing through the pump. The resultant gel is of such a texture that it can be pumped for several hundred feet without serious friction loss. This method does not restrict the movement of the nozzle man, requires only minor change in the truck, and permits the use of a standard nozzle. But changes from viscous water to gel must be made at the truck, and time must be allowed for the hose line to become cleared of the material previously used.

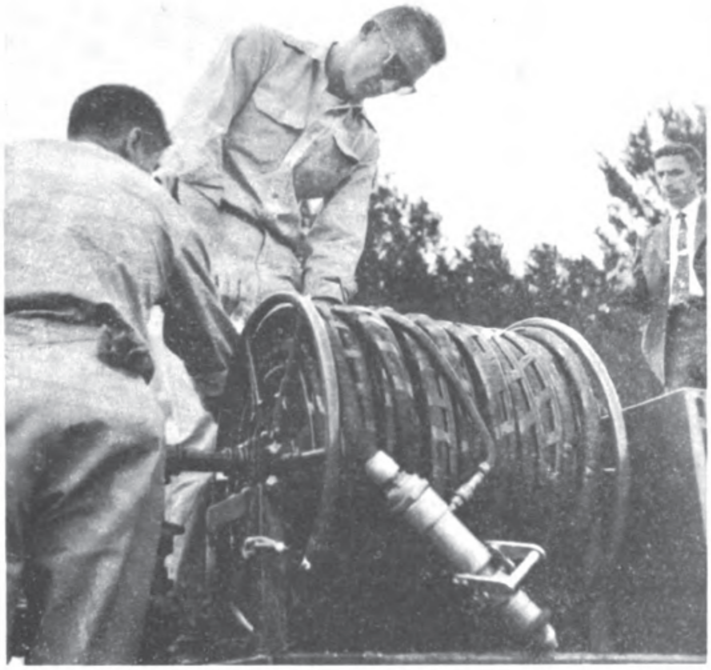

Figure 13.--Dual hose and special nozzle can be used to mix algin gel.

Figure 14.--A fire crewman carries a calcium chloride backpack and special mixing nozzle.

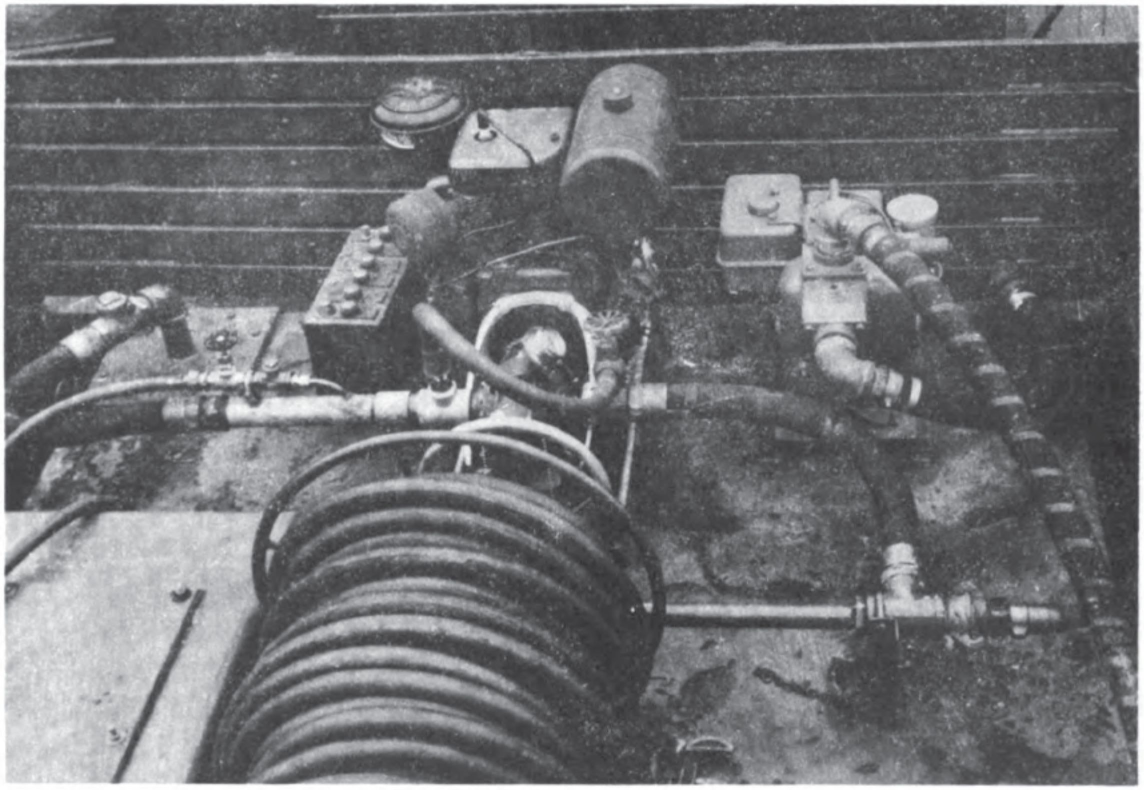

Figure 15.--Equipment for mixing calcium chloride and algin is shown at the intake side of a pump.

PUMPING AND HANDLING

Friction loss in fire hoses depends on the viscosity and gel characteristics of the viscous liquid.[3] Pressure drops with viscous water in the 100-200 centipoise range are about twice (1.9) that of plain water discharged by straight tips, and 6 (5.8) times that of plain water when sprayed by fog nozzles. The friction losses seem to be high, but the rate of delivery at that viscosity range does not seem to be seriously affected. The rate of delivery of viscous water falls about 7 percent below that of plain water when straight tips and spray tips at low and high pump pressures are used for both liquids.

In some cases a straight stream of viscous water can extend farther out than a plain water stream (fig. 16). This capability enabled a crew using viscous water to reach higher up on a burning snag than a second crew using plain water. The cohesive nature of the viscous water, which holds together longer, accounts for this phenomenon. On the other hand, viscous

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3/ A report on friction loss is being prepared by Dean L. Dibble of this Station and W. N. Carter of the Arcadia Equipment Development Center, U.S. Forest Service, Arcadia, California.

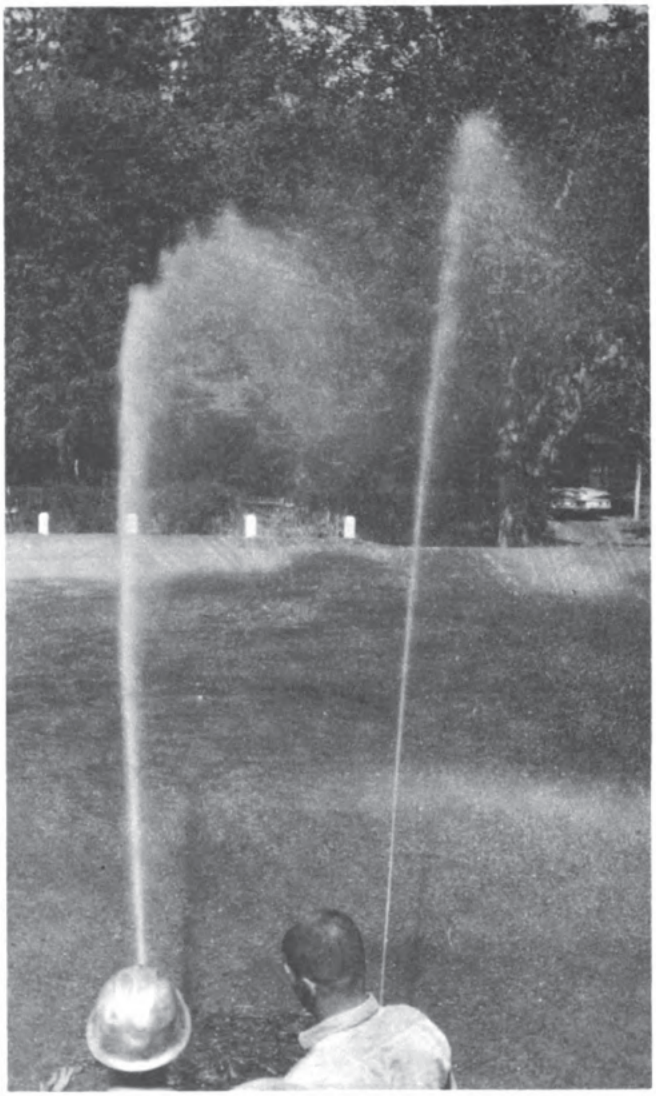


Figure 16.--Viscous water stream may reach out farther than plain water stream under the same pump pressure.

water does not produce as good a fog pattern as plain water because the individual droplets are not as small. But with most fog nozzles this pattern is entirely acceptable.

Friction loss could pose a problem, especially in cold weather. However, studies conducted by the State of Washington Department of Natural Resources show that algin gel with a viscosity exceeding 1,000 centipoise can be pumped for 1,000 feet in a 1-inch hose without serious friction loss (Tucker 1961). Numerous hose lays in excess of 1,000 feet have been reported.

Very small quantities (0.06 percent) of some viscosity agents will reduce friction loss considerably below that of plain water, perhaps as much as 40 percent. This reduction is due to the viscous water flowing with a low-friction laminar movement in a hose; plain water usually flows

with a high-friction turbulent movement. This difference presents a possibility for use in long hose lays which has not been fully explored.

The proper balance of viscosity, pump pressure, hose diameter, and nozzle has resulted in steady straight streams and adequate spray patterns in trials and in operational use.

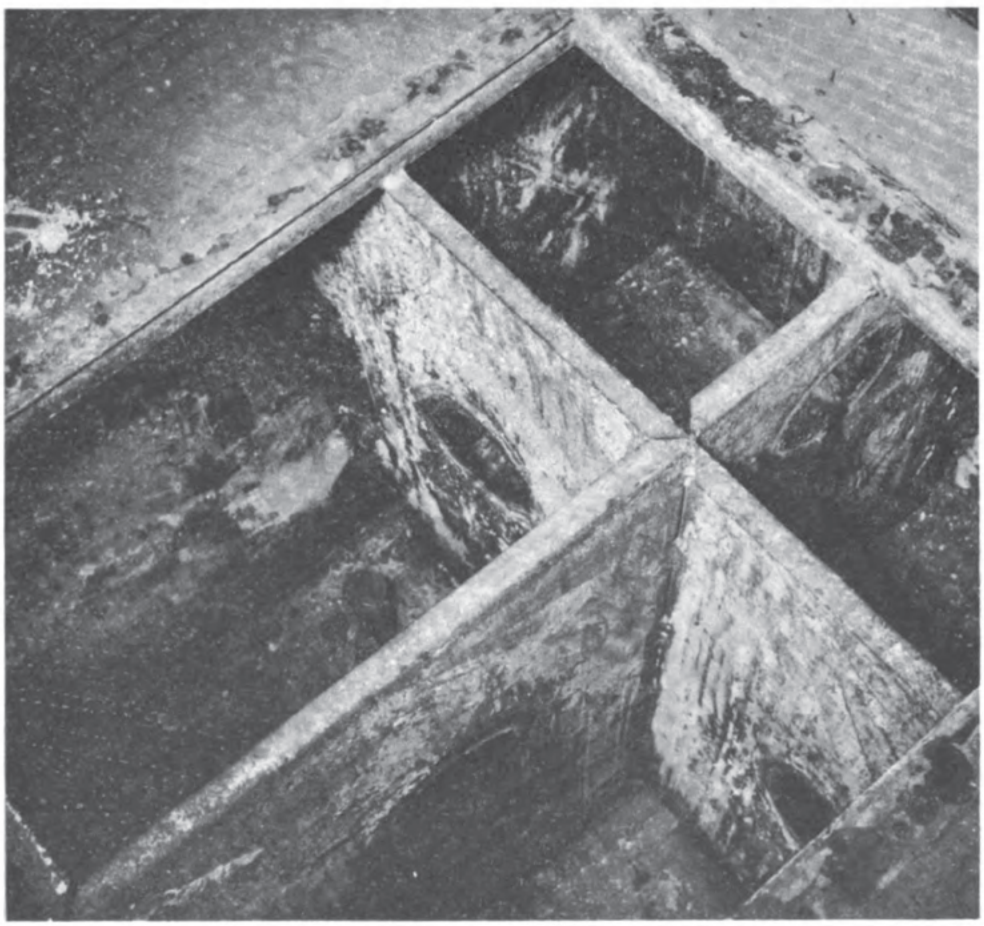


Figure 17.--Zinc alginate deposits in the interior of a fire truck's water tank.

PROBLEMS

Both algin and CMC are organic compounds that can deteriorate in part from bacterial action. In most cases spoilage was controlled or prevented by adding small amounts of preservative. In some cases, however, spoilage continued to be a problem despite the addition of several preservatives by both the manufacturer and the crew.

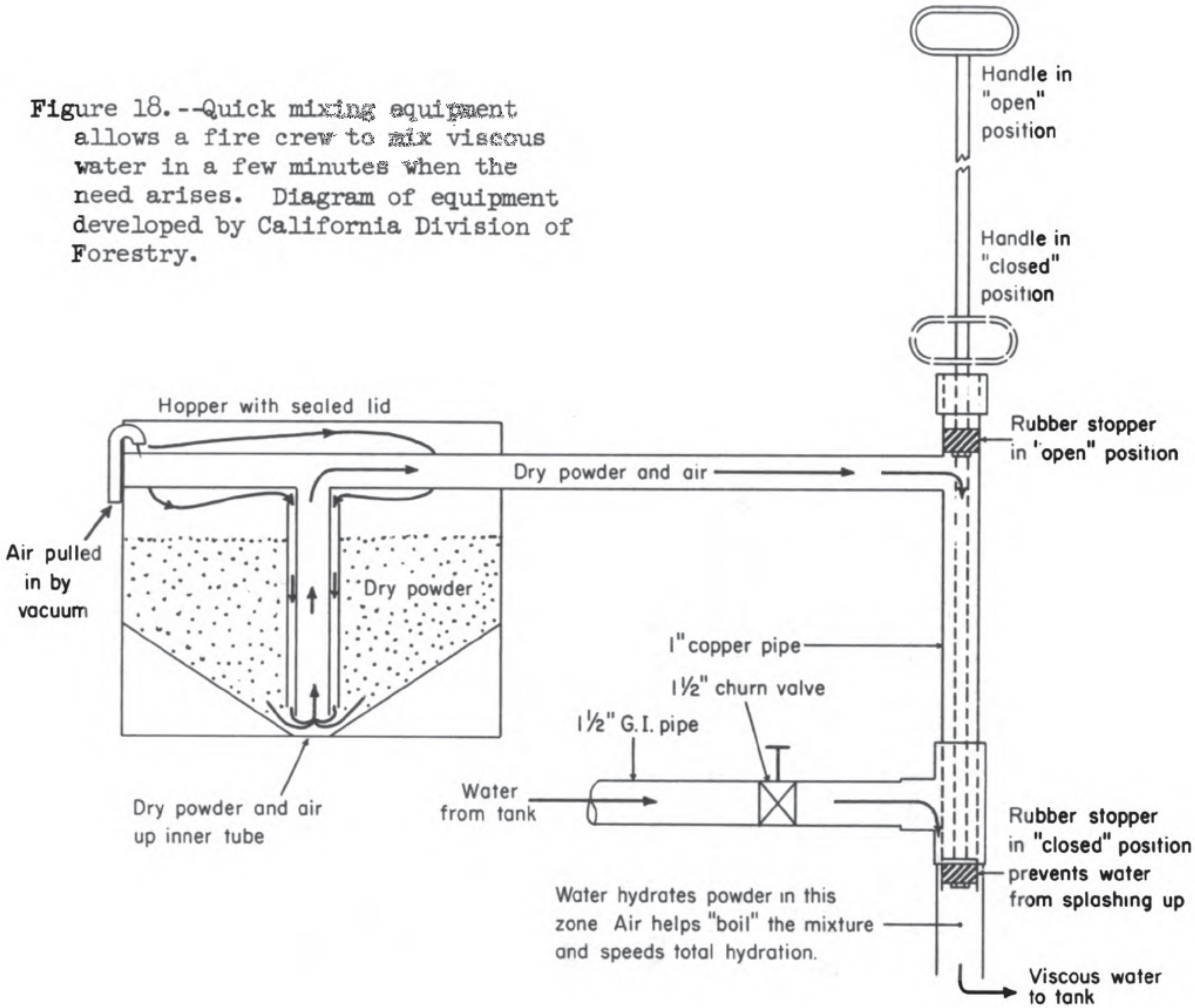
Neither CMC nor algin are truly corrosive to most materials. But both chemicals react with galvanized surfaces because they are sodium salts of organic acids. The result is a loss of galvanized plating and an insoluble zinc alginate or CMC that settles on the sides and bottom of the tank (fig. 17). This reaction varied a great deal in intensity among locations. In some places only an end-of-fire-season cleanup was necessary. However, in at least one location serious clogging of small diameter plumbing occurred. Frequent inspection should be made if either CMC or algin is used in a truck having a galvanized iron tank. Research is being conducted to find a suitable thickener that does not cause this reaction. This effect has not occurred on trucks equipped with steel- or mastic-lined tanks. A factory or "shop" paint job will not be damaged by viscous water, but touch-up paint, particularly around filler pipes and other areas where spills often occur, may blister because surfaces wetted with viscous water remain moist for a long time.

Materials containing boron, such as borax welding flux and sodium calcium borate, will gel algin-thickened water much the same way as calcium chloride. This reaction has happened accidentally when a residue of borax welding flux, remaining from construction of mixing equipment, caused a hard gel or gum that plugged the prime line of a fire truck.

Several of the problems in the use of viscous water, including spoilage and loss in viscosity, can be overcome by using quick mixing equipment. Powder could be sucked into the tank in a few seconds and be ready for use within two or three minutes. Mixing could take place as soon as the crew knows that it has a fire situation in which viscous water will help in fire control.

Fire agencies in California are developing quick mixing equipment (fig. 18). Basically it consists of a windproof hopper which stores powder and a suction pipe connected to the eductor. Upon arriving at a fire the men start the pump and throw open the proper quick-acting valves. By the time the crew pulls off the hose and tools from the truck the viscous water is mixed and ready for immediate use.

Figure 18.--Quick mixing equipment allows a fire crew to mix viscous water in a few minutes when the need arises. Diagram of equipment developed by California Division of Forestry.



SOME GUIDELINES ON USAGE

Trial and operational experience with viscous water and algin gel have indicated the following rules of what can or cannot be done:

DO use viscous water or algin gel on hot running fires in aerial fuels when rate of spread and burning intensity are sufficiently high so that fire control is difficult.

DO use viscous water when water or manpower is in short supply and rekindling is a problem.

DO use viscous water in structure fires. Viscous water causes less water damage than plain water because it does not penetrate as readily into upholstered furniture.

DO use algin gel when protecting fuel from radiation from a nearby intense fire.

DO use algin gel as a line from which to backfire if the firing can be done within a few minutes after gel application.

DON'T use viscous water when fire intensity is low and there is no problem controlling the fire with plain water or hand tools.

DON'T use viscous water or gel where penetration is required but cannot be achieved by mixing or stirring with hand tools.

DON'T use viscous water or gel where slipperiness is a critical problem, such as on steep slopes, highway, and pavement.

DON'T use viscosity agents based on a sodium salt in galvanized iron tanks without making frequent inspections.

DON'T use viscous water or gel if equipment, personnel training, or supervision is poor or if crew turnover is high.

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